EFFECT OF DIETARY PHOSPHATE ON THE VOLUNTARY CONSUMPTION OF TOWNSVILLE LUCERNE (STYLOSANTHES HUMILIS) BY CATTLE

D. A. LITTLE*

Summary
Chaffed Townsville lucerne (Stylosanthes humilis) hay containing 10% crude protein and 0.07% phosphorus (P) was fed ad libitum to four groups of yearling cattle with additions of 0, 4, 8 or 12 g P as KH₂PO₄ per day. A significant relationship (P < 0.05) was observed between daily intake of P and increases in the consumption of dry matter.

The degree of protein and energy utilization appeared to increase with P intake; it is suggested that these fractions of the diet are inefficiently utilized if the animal is in negative phosphorus balance.

Townsville lucerne, which has not received mineral fertilizer, appears to be a most unusual feed in that it has been found to contain much more crude protein (10% in dry matter) than other feeds containing similar amounts (0.07%) of P.

I. INTRODUCTION

It has been amply demonstrated that the voluntary food intake of ruminants is reduced under conditions of phosphorus (P) deficiency (Theiler, Green and du Toit 1924; du Toit, Malan and Rossouw 1930; Eckles, Gullickson and Palmer 1932; Riddell, Hughes and Fitch 1934; Martin and Peirce 1934; Kleiber, Goss and Guilbert 1936). All of these workers used synthetic rations containing low quantities of P, but adequate amounts of protein and energy, and they provided supplementary P.

The work of du Toit, Malan and Rossouw (1930) involved supplementing sheep with P at four levels; their results clearly showed greater intakes in the supplemented animals, but a quantitative relationship between P intake and increase in food consumption was not apparent. This paper reports an experiment in which such a relationship was demonstrated in young cattle.

II. MATERIALS AND METHODS

Sixteen yearling Droughtmaster (Brahman x Shorthorn) cattle, eight steers and eight heifers, were brought into individual feeding pens after having grazed speargrass (Heteropogon contortus) pasture not previously topdressed with mineral fertilizers. They were fed on chaffed hay cut from a virtually pure sward of Townsville lucerne, also untreated with fertilizer, which contained 10% crude protein and 0.07% P in the dry matter. The animals were fed ad libitum, except for an overnight fast once weekly prior to the measurement of liveweight, and

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daily samples of the feed offered and the residues were collected for analysis. These samples were bulked each week, and analysed for dry matter, nitrogen (N) and P contents. The N and P determinations were made on a Kjeldahl digest with an Autoanalyser, by phenol-hypochlorite and phosphomolybdate colour reactions respectively.

The average daily P intake of a control group comprising two steers and two heifers was determined, and three other similar groups were given \( \text{KH}_2\text{PO}_4 \) at rates calculated to provide additional amounts of 4, 8 and 12 g P/day. Dosages were checked and altered if necessary each week to maintain these differences. The supplement was added daily to the water container of each animal; these vessels were partially filled with water each morning when the supplement was dispensed, and if necessary were replenished in the afternoon. The water supply contained no detectable P.

The hay was fed for a preliminary period of 17 days, followed by an eight-week supplementation period. Daily dry matter intake was calculated for each animal every week. Liveweight after an overnight fast without water, and inorganic P in blood were measured weekly during the preliminary period and after the first two weeks of supplementation.

III. RESULTS

The mean daily dry matter intake of each group for the eight week period of supplementation was compared with the intake in the final week of the preliminary period (initial intake). The difference between the two values, expressed as a percentage of the initial intake, is shown in Figure 1, plotted

![Graph](image)

Fig. 1.—Regression of increase in dry matter intake (kg DM/day) on phosphorus intake (g/day); the increase from the mean intake, before supplementation, to the mean intake for an 8-week supplementation period, is expressed as a percentage of the initial intake. The broken curves delineate the 95% fiducial intervals.
against the daily rate of P intake. The relationship between the percentage increase in dry matter intake (y) and phosphorus intake (x) is given by the equation
\[ y = 1.98x - 5.92 \] \( (P < 0.05) \).

The increases in daily dry matter intake all occurred within the first three weeks of supplementation; after this time the intakes dropped slightly and became approximately constant. It was observed that one animal in the high supplement group was not consuming all the supplement, and the results from this individual were deleted from the calculations.

Table 1 shows the weight gain, intakes of dry matter and P, blood P and estimated P balance during the supplementation period.

An estimate of a daily requirement of 14 g P to achieve zero P balance in these animals (c. 300 kg) was made using published information on the metabolic faecal loss and true digestibility of the element (Kleiber et al. 1951), and was found not to differ appreciably from similar estimates made by Roy (1959) and the A.R.C. (1965). This figure was then used to calculate the estimated P balances shown in Table 1.

The mean digestibilities by sheep of the crude protein and organic matter in the feed were 68% and 61% respectively (Playne, unpublished data). These values were used to obtain estimates of the intakes of digestible crude protein (DCP) and digestible energy (DE), which were compared with the estimated requirements of the cattle for maintenance and gain. The results are shown in Table 2; it will be noted that in all groups the calculated intakes of DCP and DE exceeded requirement, and that the difference was least in the group receiving the high rate of supplementation.

IV. DISCUSSION

A significant positive relationship \( (P < 0.05) \) was demonstrated between daily P intake and increase in dry matter consumption following the administration of supplementary P. An inspection of the data in Table 1 will show that the observed differences in weight gain cannot be explained by differences.

**TABLE 1**

<table>
<thead>
<tr>
<th>Rate of supplementation with phosphorus (P)</th>
<th>Weight gain (kg/week)</th>
<th>Dry Matter Intake* (kg/day)</th>
<th>P Intake (g/day)</th>
<th>Blood P (mg/100ml)</th>
<th>Estimated P balance† (g/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nil</td>
<td>0.9 ± 0.2</td>
<td>5.2 ± 0.1</td>
<td>3.3 ± 0.1</td>
<td>3.3 ± 0.1</td>
<td>—11</td>
</tr>
<tr>
<td>Low</td>
<td>1.7 ± 0.2</td>
<td>5.8 ± 3.4</td>
<td>7.4 ± 0.1</td>
<td>6.0 ± 0.1</td>
<td>—7</td>
</tr>
<tr>
<td>Medium</td>
<td>1.7 ± 0.2</td>
<td>6.0 ± 0.2</td>
<td>11.4 ± 0.1</td>
<td>6.3 ± 0.3</td>
<td>—3</td>
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<tr>
<td>High</td>
<td>2.7 ± 0.7</td>
<td>6.0 ± 0.5</td>
<td>15.5 ± 0.3</td>
<td>6.7 ± 0.4</td>
<td>+1</td>
</tr>
</tbody>
</table>

*Containing 94.4% organic matter.
†Calculated on the assumption that 14 g P/day are required by 300 kg animals for zero P balance (e.g. Roy 1959; A.R.C. 1965).
‡3 animals only in this group.
TABLE 2
Calculated digestible crude protein and digestible energy intakes, and requirements for maintenance and gain of four groups of cattle.

<table>
<thead>
<tr>
<th>Rate of supplementation with phosphorus (P)</th>
<th>Approximate Digestible Crude Protein (g/day)</th>
<th>Approximate Digestible Energy (Meal/day)</th>
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<tr>
<td></td>
<td>Intake</td>
<td>Requirement*</td>
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<tr>
<td></td>
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</tr>
<tr>
<td>Nil</td>
<td>340</td>
<td>230</td>
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<tr>
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<td>380</td>
<td>300</td>
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<tr>
<td>Medium</td>
<td>370</td>
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<tr>
<td>High</td>
<td>380</td>
<td>360</td>
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<td></td>
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</tbody>
</table>

*Calculated from the equation of Preston (1966).
†Assuming 4.25 kcal/g organic matter for both feed and faeces (feed was 94.4% OM).
‡Calculated from N.R.C. (1963) recommendations.

in intake. Table 2 shows that the utilization of the feed apparently differed between groups, and that the most efficient group was that receiving the greatest amount of additional P.

This group was the only one estimated to have been in net positive P balance, and it is therefore suggested that the degree of utilization of feed is directly related to P balance. A number of workers (Riddell, Hughes and Fitch 1934; Kleiber, Goss and Guilbert 1936) observed that the efficiency of food utilization increased when supplementary P was administered to P deficient animals; the rates of supplementation used in their experiments were in most cases sufficient to allow for substantially positive P balances. Since the Townsville lucerne in this experiment was not eaten in sufficient quantity to achieve substantial weight gains, conclusions about the effect of P supplements on net efficiency of food utilization are only tentative; further work is required to test the hypothesis.

It is well recognized (Eckles, Gullickson and Palmer 1932) that the value obtained for blood P is affected by feeding and excitement. Precautions were taken to minimize such disturbances by accustoming the animals to frequent handling, and bleeding them always at the same time of day after an overnight fast. The value of blood P concentration as an indicator of P intake is indicated by the result given in Table 1. When the mean daily P intake was more than doubled, from 3.3 g to 7.4 g, mean blood P values almost doubled from 3.3 to 6.0 mg/100 ml. A further large increase in P intake to 15.5 g/day produced a rise of only 0.7 mg/100 ml in blood P. Thus, in this experiment low blood values reflected low P intakes, but higher blood levels did not allow discrimination between quite widely divergent higher intakes.

Eckles et al. (1935) claimed that a deficiency of P, uncomplicated with a protein deficiency, is not encountered in the field. Morrison’s (1937) tables of feed composition show that the few dry roughages with P contents of less than 0.1% also have low crude protein contents of less than 8%. Similarly, the figures
of Bisschop (1964) for samples of veld pasture taken over a period of 23 years show a mean crude protein content of 6.85%, and for P of 0.074%. The highest recorded crude protein level was 14.26%, and was associated with a P content of 0.110%.

Thus it is apparently generally true that low crude protein levels are associated with low P content. In the introduction it was pointed out that in order to obtain adequate levels of protein and energy, and inadequate levels of P, the early workers on P deficiency had to use rations containing protein concentrates of low P content, e.g. blood meal or gluten. The ration utilized in the present experiment met these criteria without modification; in this respect, therefore, Townsville lucerne is a most unusual fodder.

V. ACKNOWLEDGMENTS

I am indebted to Dr. M. J. Playne for permission to use his data on the digestibility of the Townsville lucerne, and to Drs. D. R. Lamond and L. J. Lambourne for valuable discussions. I wish also to thank Messrs. R. L. Southwell and G. H. Sherrington for able technical assistance, and R. Field for care of the experimental animals.

VI. REFERENCES